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Thank you all very much. It's a great pleasure to be here today with our partners from here and around the globe, in industry, academia, and government.

Mike Griffin and I have stated repeatedly that to achieve the *Vision for Space Exploration*, NASA is compelled to seek out international and commercial collaboration. We must maintain and strengthen existing international partnerships and build new ones, to enable a robust space exploration program. This desire is predicated on the guidance of the Vision itself, which calls on us to seek out international participation as we embark on this new era of exploration.

As you know, 2005 marked the creation of the Exploration Systems Architecture Study, ESAS, which laid the foundation for the transportation elements to get us back to the lunar surface. In 2006, I met with many of our international partners and there were meetings throughout the year, in the U.S. and abroad, to develop the Global Exploration Strategy.

2007 will see continued work on the Global Exploration Strategy as well as continued work on maturing our lunar architecture. Both efforts will require the continued intensive commitment and work by Doug Cooke, our Deputy Chief for Exploration. In 2007, we also will develop an updated Mars exploration architecture that factors in the transportation architecture elements that we have already defined as well as looking at how we can further maximize the synergy between our lunar and Mars planning.

Global Exploration Strategy

This conference marks an important milestone in the Vision with the creation of the Global Exploration Strategy. Today I'd like to tell you about the Global Exploration Strategy – what it is, what it means and how it will improve our efforts to explore space including returning to the Moon and then going on to Mars and beyond.

I'll also discuss the U.S. contribution to this strategy -- our Lunar Architecture, which puts forward our priorities in lunar exploration. In doing so, I hope to answer some key questions about why we're going and what we hope to gain, not only in terms of scientific discovery but in technological advancements and innovations that can potentially yield economic and health benefits that will improve our lives on Earth.

The Global Exploration Strategy has been a work in progress to which more than 1,000 people from around the world and experts of 14 space agencies have contributed. Together we assessed our aspirations, creating a strong foundation for further discussion and cooperation.

The initial phase of the Global Exploration Strategy is focused on the Moon. With that in mind we have worked together to develop six broad themes that answer the critical "Why" question, defining our common understanding of the value of lunar exploration. These themes redefine our Moon as much more than a mere destination.

These six themes are:

- First, the Moon is a foothold to further exploration, preparing us for future human and robotic missions to Mars and other destinations.

- Second, the Moon is a unique laboratory where we can pursue scientific activities addressing fundamental questions about the Earth, the solar system, the universe, and our place in them.
- Third, the Moon is an opportunity to extend sustained human presence on the Moon.
- Fourth, we will expand Earth's economic sphere to encompass the Moon, generating economic advancement and technological innovation that can benefit life on Earth.
- Fifth, the international collaboration essential to accomplishing the goals of this mission will enhance collective security by providing challenging, shared, and peaceful global activity.
- And finally, a vibrant exploration program will engage, inspire, and educate the public bringing hope and wonder to old and young alike.

This international collaboration also addressed the "What" question, and provided more detailed information on the specific activities that can be undertaken in support of these themes. The discussion resulted in the definition of 180 specific lunar exploration objectives that various stakeholders have identified, grouped into 23 categories. The objectives, some of which NASA will support and pursue, cover a range of activities that include power generation, communication, life support and habitat, environmental characterization and lunar resource utilization.

The conquest of space has been marked by many thrilling moments of international cooperation, from the 1975 docking of the Apollo and Soyuz capsules in Earth's orbit to the multi-national crews of the ISS today. The Global Exploration Strategy builds on this history and sets the stage for expanding the horizons of cooperation and embracing a variety of collaborations.

Lunar Architecture

Based on some of the themes and objectives set forth in the Global Exploration Strategy and consistent with US national goals, today NASA is rolling out its initial Lunar Architecture.

It is an open architecture, designed to be added to, enlarged and completed by others who come after us, in order to evolve and allow the journey to continue to Mars and to other destinations. That architecture consists of three main and essential components.

- First, we see the Moon not as a brief rendezvous, but as an outpost. Our objective is to create an enduring, sustainable human and robotic presence that will open up vastly greater opportunities for science, research and technological development.
- Second, we will be sending robotic trailblazers to provide data on the best location to develop human habitation – and what we can expect when we get there.
- Third is location. We are aiming toward the lunar poles for a variety of reasons, including the fact that they are thermally more moderate. Specific locations offer a high percentage of sunlight, which of course increases daylight operations activity and can be utilized for solar power. The potential for hydrogen and other volatiles increases the ability to "live off the land," while a pole outpost cuts down on Low Earth Orbit (or LEO) loiter by allowing more frequent launch opportunities requiring only a single communication asset, with one backup.

This architecture is a foundation for moving forward that will be further shaped and defined as this work matures and based on a continued dialogue with national space agencies as we share our national priorities and architectures as well as ongoing discussions with commercial entities.

Next Steps

As we begin the next phase of our lunar architecture studies, we will be working with all interested space agencies to move beyond our initial strategy discussion to better understand where we have common interests, paving the way for collaborative efforts among our nations. We welcome our partners' input on ways we can leverage our national activities, how we might diversify our activities, and where we can have the greatest scientific impact.

Following this conference, NASA will host the fourth meeting of the international coordination team here in Houston. During the meeting, NASA will brief the details of our Lunar Architecture Team study and other space agencies will provide briefings on their national strategies and architectures.

In 2007, NASA will initiate "Cycle 2" of the Lunar Architecture Team, with the aim of identifying linkages to NASA's initial lunar architecture plans, including potential commercial and international involvement. A key focus will be the further development of a framework that will guide future international coordination and collaboration efforts. The principles for this framework have already been identified in the way the Global Exploration Strategy has been developed, calling for a mechanism that is open and inclusive, flexible and evolutionary, effective, defined by our mutual interests.

As we move forward, we will see many different kinds and levels of cooperation that result from this framework. In some cases, international lunar exploration efforts in the future will coalesce around one single, integrated activity, much like the International Space Station today. At other times, space agencies may choose to send independent missions to the Moon or conduct independent studies while utilizing shared support services.

Independent robotic missions to the moon exist today. These missions will contribute to our knowledge and help pave the way for the future.

The European Space Agency's Smart-1 recently concluded its scientific exploration of the Moon, mapping impact craters, studying volcanic and tectonic processes, investigating the poles, and setting the stage for further exploration.

Japan's SELENE will be the largest lunar mission since Apollo, and there are other planned lunar exploration missions include ones from China and Russia.

A striking example of the global spirit is India's Chandrayaan-1 to be launched in early 2008. Along with its primary payload of Indian scientific instruments, the craft will carry aboard two instruments from Europe and two from the U.S., one of which will be a tiny Synthetic Aperture Radar that will scout the shadow lands of the Moon's poles for the characteristic signatures of water ice, and the other of which will scout for key mineral concentrations that can be used as a resource by lunar explorers of the future.

This spirit also lives in NASA's Lunar Reconnaissance Orbiter, to be launched later in 2008, which will advance the search for water and provide critical knowledge about the temperatures and lighting conditions at the lunar poles. It also will engage in a detailed mapping of the Moon's surface, especially its less well known polar regions, helping us to choose a suitable landing site for future missions.

In order to optimize the benefits from these upcoming missions, it is important that we develop a multilateral commitment to a common set of standards, most immediately in the area of data.

I am pleased to say that we are beginning to do that. Last week (28-30 November), scientists from ESA, India, Japan, Russia, and the United States met at a Lunar Reconnaissance Orbiter (LRO) Science Meeting. The meeting facilitated coordination among LRO payload instrument teams, and established a technical basis for potential cooperative observations with other international missions.

But most importantly, this working group will endeavor to create a common coordinate system with international missions to the Moon. This group also will propose and discuss standard calibration targets for all lunar missions to observe. We can do more, in the area of spectrum management and common hardware interfaces to ensure that we maximize openness and flexibility in all parts of this evolving lunar architecture.

NASA's Lunar Architecture is squarely focused on the human exploration priorities set forth in the Vision for Space Exploration and we are moving forward aggressively with developing and building the next generation of space vehicles that will take us to the Moon and beyond, one of the many activities so ably managed and overseen by Exploration Chief Doc Horowitz.

Constellation Progress

So let me now tell you where we stand in this work and some of the activities we are engaged in to move this effort forward. This summer, the contract for our Crew Exploration Vehicle, Orion, was awarded to Lockheed Martin, and DDT&E work for the Ares J-2X engine and First Stage is already underway with ATK Thiokol and Pratt Whitney Rocketdyne with anticipated contract award dates of no later than February 2007 and March 2007, respectively. The request for proposals for the Ares I Upper Stage production contract and Upper Stage Instrument Unit work should be issued early in 2007, and NASA is driving toward selection of a contractor for this work by early fall.

Orion, which will carry human passengers into orbit by 2014, will support the International Space Station after the Shuttle is retired. And by 2018 to 2020, when the heavy lift launch vehicle ARES V is built, Orion will take us back to the Moon.

We also have inaugurated an exciting new program to open up the realm of space flight in a major way to the entrepreneurial spirit of the private sector, with the award of demonstration agreements totaling a half billion dollars in the first phase of the COTS project to Rocketplane Kistler and SpaceX to develop a commercial orbital transportation capability.

Unique in NASA's history, the proposed cargo transports will be owned and financed primarily by the private sector. It is an extremely challenging program, but we have turned to the private sector because we believe that the competitive dynamics of the marketplace will ultimately lower the costs of space launch, creating a viable economic base for Earth-to-orbit transportation, and – critically – freeing up government resources that can then be invested in exploration and discovery.

As our explorers head to the Moon and beyond, we will continue to look for exciting and innovative ways to expand the Earth's economic sphere, engaging private sector entrepreneurs and creating exciting new business opportunities along the way.

New Opportunities on the Moon

Creating a sustained human presence on the Moon will be a learning experience – in every possible way. In learning to adapt and survive in a foreign and inhospitable environment we must learn to use the land and its resources not just to sustain us, but to propel us forward to new destinations.

It will test our imagination and our will, taking us to the farthest limits of science and forcing us to go beyond…And in doing so it will open up a bounty of knowledge about ourselves and the universe we inhabit.

Much of it will be unpredictable, but without prejudicing or precluding our future activities on the Moon, one can speculate on some possibilities.

Let me look briefly to the past.

In U.S. history, the pioneer spirit has many emblems, but one of the most resonant is that of the sod-busters, the families who settled the Great Plains of the American West in the 19th century. It was a beautiful but harsh environment: endless plains covered by tall grasses, baked by the sun in summer, frozen by bitter arctic winds sweeping down unobstructed from the north in the winter. With few trees or other materials from which to construct shelter, they dug up blocks of the grassy soil – the sod – and laid them one on top of another to form sod houses.

The pioneers of the 21st century will be settling an even less hospitable environment, of course, but like those that went before them they will have to mould and manipulate the environment to meet their urgent needs – first for survival, then for expansion. Instead of sod-busters, they will be regolith-busters, at first simply piling up the lunar soil to shield their habitats from cosmic radiation, but in time perhaps using it to manufacture ceramics, glass and other more stable building materials.

So far away from home, they will have to learn to live off the land, extracting the resources they need *in situ*. At least some of these will be, quite literally, lying about at our feet when we get to the Moon. The first is the breath of life. Kilogram for kilogram, the lunar soil is almost 50% oxygen. All we need to do is release it from the rocks with which it is now conjoined.

As I mentioned, Chandrayaan-1 and NASA's Lunar Reconnaissance Orbiter will be looking for water, which we believe may be stored as ice in the Moon's polar regions. As you know, there are a number of uses for water. You can break it down into its constituent elements of oxygen and hydrogen to make rocket fuel. If we are able to generate rocket propellant in significant quantities, the Moon will become a refueling stop on our highway out into the solar system. And the hydrogen from water could be a possible basis of a lunar hydrogen economy.

But there are other sources of energy as well. Some areas at the poles experience almost perpetual sunlight, making them prime locations for solar farms that could produce as much energy as we will ever need – and more. In fact, some speculate that energy production on the Moon may be so efficient that we will be sending it back to Earth to power this planet's seemingly insatiable needs. Then, too, we may be able to exploit Moon light and shadow, and the extreme differences of temperature between them, to produce energy.

Lunar Science

But our ideas for opportunity do not stop with energy production, new energy resources or technology innovations. The opportunities for conducting science are numerous and just as rewarding.

One of the Moon's most exciting potentials is what it may be able to tell us about Earth. If one thinks of our own planet's history as a book, then it is one in which the first chapters have been ripped out. Billions of years of wind and water erosion and a churning, recycling crust have wiped away the early part of our story. If current theories are correct, however, and the Moon split off from the Earth due to some cosmic collision some four and a half billion years ago, that early history may well be preserved on the Moon, offering concrete clues about the surface and atmospheric conditions that prevailed when life first arose.

Similarly, the absence of erosion on the Moon's surface means that it retains a history of events that have occurred in the Earth-Moon system over those four and one-half billion years. Being so close, the Moon's surface gives us a well-preserved history of our own bombardment by asteroids and planetary debris; and as there is no atmosphere to filter and burn up incoming particles, the lunar regolith holds a comparable history of the Sun's output and its variation over time, offering important insights into climate change and the evolution of life here on Earth.

The Moon also may turn out to be an ideal platform from which to make observations of our universe. I am not here suggesting any time line, or trade off between orbital observatories and those that might be Moon-based.

To a great extent, the issue is one of cost, and as we project into the future, we can be sure that an extended presence on the Moon will dramatically lower costs and open up options that are not now available. Looking to that future, some have proposed building large, distributed aperture arrays that would have resolutions on the order of one-millionth of a second of arc. Such telescopes could see sunspots on nearby stars and even the planets orbiting them. The immense quiet on the far side of the Moon, shielded from electromagnetic emanations from Earth also would provide an ideal environment for giant radio telescopes to probe into the origins of our universe.

Benefiting Our World

Of course, much of what we gain from exploring and settling the Moon will not be in what we find on it, or in the observations we make from it, but in the scientific and technological progress that will come in the process of doing it. And much of that will have direct economic and health benefits for those of us who remain behind on Earth.

Clearly, a sustained presence will mean refining the science of recycling bio-waste to near 100% efficiency. I mentioned the water that we may find in permanently shadowed craters on the Moon. These craters are located in polar areas and have temperatures that hover around a chilly 40 degrees Kelvin.

How do you extract the water, if it is there, under such conditions? One assumes with robots. But such daunting terrain, with temperatures close to absolute zero, will demand extraordinary advances in robot technology, including artificial intelligence.

The terrestrial market for robotics is just beginning to take off. The need for lightweight, autonomous robots for support of the elderly and handicapped, industrial applications, and rescue and hazardous conditions is clear, but the applications for near-intelligent robots are really almost infinite.

I mentioned the possibility of using a hydrogen-based lunar economy. Many believe that clean-burning hydrogen is the fuel of our future, and there’s little question that the technologies that enable the practical utilization of hydrogen as a wide-spread energy source would redefine our terrestrial energy economy.

Sustained settlement on the Moon will mean surmounting a whole new list of medical challenges, including the ability to diagnose and treat illness and injury on board the spacecraft or inside the habitat when evacuation to Earth is not an option. Other important capabilities will 1) include the ability to detect and eliminate pathogens and toxins in the environment, 2) extending the shelf-life of medicines, and 3) developing "smart" medical devices that can be used by laymen and require little or no maintenance and supplies.

Robot assisted surgery will likely be a huge area of investigation. Of course, supplying improved health care and greater opportunities for independence for an aging population is one of the greatest economic challenges that industrialized nations face today. It is perhaps one of the greatest political challenges as well.

In this sense, we see that our Vision of Space Exploration is not something "out there" – it is in fact woven tightly into the fabric of our future wellbeing.

What I have talked about today are just a few examples. But what becomes clear is that settling the Moon will touch and enliven several scientific fields – both pure and applied – and have direct economic ramifications on our terrestrial economy from which all nations, and humankind as a whole, can benefit.

The flexible structure of participation means that many can collaborate, at almost every level. For the human missions, we at NASA will be providing the core U.S. transportation architecture, initial communication and navigation, and initial EVA capability. But after that, the door is wide open. And the needs – as even this brief overview of what it will mean to actually establish a presence on the Moon – are practically endless.

I have focused today on the Moon, but the Moon in our vision is but part of a grander scheme which will eventually take humans to Mars and beyond. In this process, the Moon will be our laboratory and our school beyond low Earth orbit, where we conduct the experiments and learn the lessons that will enable us to continue on.

The Moon will be the first summit we mount in our quest to points beyond. And it will be in that quest that we show ourselves and posterity the practical possibility and the full potential of international cooperation – the genius and spirit of humankind united in the service of one common goal…

To test our better natures…

To better our loftiest achievements…

To achieve great ambitions for the benefit of all.

Decades from now, when humans routinely live and work on the lunar surface and humankind is preparing its journey to Mars, all of us here today can look back and remember that we were here, together, at the beginning, together in international and commercial collaboration that enabled a sustained human presence other new worlds.

Thank you all very much.